

UTILITY PATENT APPLICATION TRANSMITTAL

(Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.
JEL 31232

Total Pages in this Submission
3

TO THE ASSISTANT COMMISSIONER FOR PATENTS

Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

APPARATUS AND METHOD FOR OFDM COMUNICATION

and invented by:

Hiroaki SUDO

If a **CONTINUATION APPLICATION**, check appropriate box and supply the requisite information:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: _____

Which is a:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: _____

Which is a:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: _____

Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having 26 pages and including the following:
 - a. ☒ Descriptive Title of the Invention
 - b. ☐ Cross References to Related Applications (if applicable)
 - c. ☐ Statement Regarding Federally-sponsored Research/Development (if applicable)
 - d. ☐ Reference to Microfiche Appendix (if applicable)
 - e. ☒ Background of the Invention
 - f. ☒ Brief Summary of the Invention
 - g. ☒ Brief Description of the Drawings (if drawings filed)
 - h. ☒ Detailed Description
 - i. ☒ Claim(s) as Classified Below
 - j. ☒ Abstract of the Disclosure

UTILITY PATENT APPLICATION TRANSMITTAL
(Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.
JEL 31232

Total Pages in this Submission
3

Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*
- a. ☒ Formal Number of Sheets 4
- b. ☐ Informal Number of Sheets _____
4. ☒ Oath or Declaration
- a. ☒ Newly executed *(original or copy)* ☐ Unexecuted
- b. ☐ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*
- c. ☒ With Power of Attorney ☐ Without Power of Attorney
- d. ☐ DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application,
see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference *(usable if Box 4b is checked)*
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied
under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby
incorporated by reference therein.
6. ☐ Computer Program in Microfiche *(Appendix)*
7. ☐ Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all must be included)*
- a. ☐ Paper Copy
- b. ☐ Computer Readable Copy *(identical to computer copy)*
- c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☒ Assignment Papers *(cover sheet & document(s))*
9. ☐ 37 CFR 3.73(B) Statement *(when there is an assignee)*
10. ☐ English Translation Document *(if applicable)*
11. ☒ Information Disclosure Statement/PTO-1449 ☒ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Acknowledgment postcard
14. ☐ Certificate of Mailing
- ☐ First Class ☐ Express Mail *(Specify Label No.):* _____

UTILITY PATENT APPLICATION TRANSMITTAL
(Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.
JEL 31232

Total Pages in this Submission
3

Accompanying Application Parts (Continued)

15. ☒ Certified Copy of Priority Document(s) (if foreign priority is claimed)

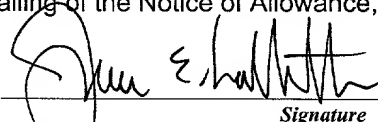
16. ☐ Additional Enclosures (please identify below):

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	9	- 20 =	0	x \$18.00	\$0.00
Indep. Claims	6	- 3 =	3	x \$78.00	\$234.00
Multiple Dependent Claims (check if applicable) <input type="checkbox"/>					\$0.00
BASIC FEE					\$690.00
OTHER FEE (specify purpose)					\$0.00
TOTAL FILING FEE					\$924.00

- ☒ A check in the amount of **\$924.00** to cover the filing fee is enclosed.
- ☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. **19-4375** as described below. A duplicate copy of this sheet is enclosed.
- ☐ Charge the amount of _____ as filing fee.
- ☒ Credit any overpayment.
- ☒ Charge any additional filing fees required under 37 C.F.R. 1.16 and 1.17.
- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).


Signature

James E. Ledbetter, Reg. No. 28,732
Stevens, Davis, Miller & Mosher, LLP
1615 L Street N.W., Suite 850
P.O. Box 34387
Washington, D.C. 20043-4387
Telephone: 202/408-5100
Facsimile: 202/408-5200

Dated: August 9, 2000

cc:

Figure 1 consists of 10 sub-charts, labeled (a) through (j), each representing a different demographic or attitudinal variable. Each chart displays the percentage of respondents for that variable, broken down by two time points: 2008 (represented by light-colored bars) and 2012 (represented by dark-colored bars). The charts are organized as follows:

- (a) Age:** Categories include 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75+.
- (b) Sex:** Categories are Male and Female.
- (c) Education:** Categories include Less than high school, High school, Some college, Bachelor's, Master's, and Doctorate.
- (d) Income:** Categories include Less than \$10,000, \$10,000-\$19,999, \$20,000-\$29,999, \$30,000-\$39,999, \$40,000-\$49,999, \$50,000-\$59,999, \$60,000-\$69,999, \$70,000-\$79,999, \$80,000-\$89,999, \$90,000-\$99,999, and \$100,000+.
- (e) Employment:** Categories include Full-time, Part-time, and Unemployed.
- (f) Political Party:** Categories include Republican, Democrat, and Other.
- (g) Religion:** Categories include No religion, Protestant, Catholic, Jewish, Muslim, and Other.
- (h) Race:** Categories include White, Black, Hispanic, Asian, and Other.
- (i) Marital Status:** Categories include Married, Single, Divorced, and Widowed.
- (j) Attitude towards gay, lesbian, and transgender people:** Categories include Strongly oppose, Oppose, Neutral, Support, and Strongly support.

In all charts, the 2012 data generally shows a shift towards more liberal or supportive attitudes compared to 2008, particularly in the 'Attitude' chart (j) and among younger and more educated groups in other categories.

Figure 1 consists of 10 sub-charts, labeled (a) through (j), each representing a different demographic or attitudinal variable. Each chart displays the percentage of respondents for that variable, broken down by two time points: 2008 (represented by light-colored bars) and 2012 (represented by dark-colored bars). The charts are organized as follows:

- (a) Age:** Categories include 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75+.
- (b) Sex:** Categories are Male and Female.
- (c) Education:** Categories include Less than high school, High school, Some college, Bachelor's, Master's, and Doctorate.
- (d) Income:** Categories include Less than \$10,000, \$10,000-\$19,999, \$20,000-\$29,999, \$30,000-\$39,999, \$40,000-\$49,999, \$50,000-\$59,999, \$60,000-\$69,999, \$70,000-\$79,999, \$80,000-\$89,999, \$90,000-\$99,999, and \$100,000+.
- (e) Employment:** Categories include Full-time, Part-time, and Unemployed.
- (f) Political Party:** Categories include Republican, Democrat, and Other.
- (g) Religion:** Categories include No religion, Protestant, Catholic, Jewish, Muslim, and Other.
- (h) Race:** Categories include White, Black, Hispanic, Asian, and Other.
- (i) Marital Status:** Categories include Married, Single, Divorced, and Widowed.
- (j) Attitude towards gay, lesbian, and transgender people:** Categories include Strongly oppose, Oppose, Neutral, Support, and Strongly support.

In all charts, the 2012 data generally shows a shift towards more liberal or supportive attitudes compared to 2008, particularly in the 'Attitude' chart (j) and among younger and more educated groups in other categories.

Figure 1 consists of 10 sub-charts, labeled (a) through (j), each representing a different demographic or attitudinal variable. Each chart displays the percentage of respondents for that variable, broken down by two time points: 2008 (represented by light-colored bars) and 2012 (represented by dark-colored bars). The charts are organized as follows:

- (a) Age:** Categories include 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75+.
- (b) Sex:** Categories are Male and Female.
- (c) Education:** Categories include Less than high school, High school, Some college, Bachelor's, Master's, and Doctorate.
- (d) Income:** Categories include Less than \$10,000, \$10,000-\$19,999, \$20,000-\$29,999, \$30,000-\$39,999, \$40,000-\$49,999, \$50,000-\$59,999, \$60,000-\$69,999, \$70,000-\$79,999, \$80,000-\$89,999, \$90,000-\$99,999, and \$100,000+.
- (e) Employment:** Categories include Full-time, Part-time, and Unemployed.
- (f) Political Party:** Categories include Republican, Democrat, and Other.
- (g) Religion:** Categories include No religion, Protestant, Catholic, Jewish, Muslim, and Other.
- (h) Race:** Categories include White, Black, Hispanic, Asian, and Other.
- (i) Marital Status:** Categories include Married, Single, Divorced, and Widowed.
- (j) Attitude towards gay, lesbian, and transgender people:** Categories include Strongly oppose, Oppose, Neutral, Support, and Strongly support.

In all charts, the 2012 data generally shows a shift towards more liberal attitudes and higher education levels compared to 2008, while the 2008 data shows a higher proportion of respondents in more conservative and lower-income groups.

Figure 1 consists of 10 bar charts, labeled (a) through (j), each representing a different demographic or attitudinal variable. Each chart compares the percentage of respondents in five age groups (18-24, 25-34, 35-44, 45-54, and 55+) for two survey years: 2008 (light bars) and 2012 (dark bars). The y-axis for all charts represents the percentage of respondents, ranging from 0% to 100%.

- (a) Age:** Shows the percentage of respondents in each age group. The 18-24 group is the largest in both years, around 20-25%.
- (b) Sex:** Compares the percentage of male and female respondents. Males are consistently around 50%, while females are around 50%.
- (c) Education:** Compares the percentage of respondents with different levels of education (High School, Some College, Bachelor's, Master's, Doctorate). The High School group is the largest, around 20-25%.
- (d) Income:** Compares the percentage of respondents in different income brackets. The lowest income bracket is the largest, around 20-25%.
- (e) Employment:** Compares the percentage of respondents who are employed, unemployed, or retired. The employed group is the largest, around 60-65%.
- (f) Political Party:** Compares the percentage of respondents who identify with different political parties (Democrat, Republican, Independent, etc.). The Democrat group is the largest, around 50-55%.
- (g) Religion:** Compares the percentage of respondents who identify with different religious groups (Christian, Jewish, Muslim, etc.). The Christian group is the largest, around 70-75%.
- (h) Race:** Compares the percentage of respondents who identify with different racial groups (White, Black, Asian, etc.). The White group is the largest, around 70-75%.
- (i) Marital Status:** Compares the percentage of respondents who are married, single, divorced, or widowed. The married group is the largest, around 50-55%.
- (j) Attitude towards gay, lesbian, and transgender people:** Compares the percentage of respondents who have a positive or negative attitude towards these groups. The positive attitude group is the largest, around 60-65%.

Figure 1 consists of 10 bar charts, labeled (a) through (j), each representing a different demographic or attitudinal variable. Each chart compares the percentage of respondents in five age groups (18-24, 25-34, 35-44, 45-54, and 55+) for two survey years: 2008 (light bars) and 2012 (dark bars). The y-axis for all charts represents the percentage of respondents, ranging from 0% to 100%.

- (a) Age:** Shows the percentage of respondents in each age group. The 18-24 group is the largest in both years, around 20-25%.
- (b) Sex:** Compares the percentage of male and female respondents. Males are consistently around 50%, while females are around 50%.
- (c) Education:** Compares the percentage of respondents with different levels of education (High School, Some College, Bachelor's, Master's, Doctorate). The High School group is the largest, around 20-25%.
- (d) Income:** Compares the percentage of respondents in different income brackets. The lowest income bracket is the largest, around 20-25%.
- (e) Employment:** Compares the percentage of respondents who are employed, unemployed, or retired. The employed group is the largest, around 60-65%.
- (f) Political Party:** Compares the percentage of respondents who identify with different political parties (Democrat, Republican, Independent, etc.). The Democrat group is the largest, around 50-55%.
- (g) Religion:** Compares the percentage of respondents who identify with different religious groups (Christian, Jewish, Muslim, etc.). The Christian group is the largest, around 70-75%.
- (h) Race:** Compares the percentage of respondents who identify with different racial groups (White, Black, Asian, etc.). The White group is the largest, around 70-75%.
- (i) Marital Status:** Compares the percentage of respondents who are married, single, divorced, or widowed. The married group is the largest, around 50-55%.
- (j) Attitude towards gay, lesbian, and transgender people:** Compares the percentage of respondents who hold different attitudes (Strongly Oppose, Oppose, Neutral, Support, Strongly Support). The 'Strongly Oppose' and 'Oppose' groups are the largest, around 40-45%.

APPARATUS AND METHOD FOR OFDM COMMUNICATION

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to a communication apparatus based on an OFDM (Orthogonal Frequency Division Multiplexing) system.

10 Description of the Related Art

A conventional OFDM-based communication apparatus generally uses coherent detection or delay detection as a demodulation system. First, a conventional OFDM communication apparatus that carries out coherent
15 detection will be explained with reference to FIG.1. FIG.1 is a block diagram showing a configuration of a conventional OFDM communication apparatus that carries out coherent detection.

In the transmission system in FIG.1, a transmission
20 signal is subjected to QPSK modulation processing for every subcarrier by QPSK modulation section 41. The transmission signal subjected to QPSK modulation is subjected to IFFT (inverse Fourier transform) processing and thereby frequency-division multiplexed by IFFT
25 section 42. The transmission signal subjected to IFFT processing is transmitted via antenna 43.

The signal transmitted via antenna 43 has a frame configuration as shown in FIG.2. FIG.2 is a schematic

006080" 95052950

diagram showing a frame format used for the conventional OFDM communication apparatus. As shown in FIG.2, the signal transmitted via antenna 43 is configured by preamble section 51, pilot symbol section 52 and message section 53 in an old-to-new time sequence. Each signal with this frame configuration is sent carried on one packet.

In the reception system in FIG.1, the signal sent from the other end of communication is received via antenna 43. Here, the other end of communication above has the same configuration as that shown in FIG.1 and the signal sent from this other end of communication is subjected to the same processing as that in the transmission system described above.

The signal received via antenna 43 is subjected to FFT (Fourier transform) processing by FFT section 44. Thus, a signal carried by each subcarrier is extracted. The signal extracted by FFT section 44 is subjected to coherent detection processing by coherent detection section 45. In this way, a demodulated signal is extracted.

Here, the coherent detection processing carried out by coherent detection section 45 will be explained with reference to FIG.3. FIG.3 is a block diagram showing an internal configuration of coherent detection section 45 in the conventional OFDM transmission apparatus that carries out coherent detection.

Coherent detection section 45 performs

transmission path estimation using a pilot symbol in the reception signal and performs coherent detection processing by carrying out transmission path compensation on the reception signal using the
 5 transmission path estimation information obtained.

In FIG.3, the reception signal (RX1) is sent to complex multiplication section 62, level detection section 63 and multiplication section 65 via switching section 61. This reception signal (RX1) is the signal
 10 extracted from FFT section 44 shown in FIG.1.

Here, the reception signal (RX1) is expressed in the following expression:

$$RX1 = R1 \times e^{j\theta 1} \times TX \quad -①$$

where, R1 is an amplitude variation due to fading, etc. and $\theta 1$ is a phase variation due to fading, etc. and TX is a signal transmitted from the other end of communication (transmission signal).
 15

Moreover, the signal in the pilot section of the reception signal expressed in expression ① above, that is, the reception signal (RXP1) in the pilot section is expressed in the following expression:
 20

$$RXP1 = R1 \times e^{j\theta 1} \times Pilot \quad -②$$

where, Pilot is a pilot symbol.

Complex multiplication section 62 estimates a transmission path characteristic by carrying out complex multiplication processing using the reception signal (RX1) and pilot symbol (Pilot). That is, a transmission path characteristic (Profile1) as shown in the following
 25

expression is obtained by multiplying the reception signal (RXPl) in the pilot symbol section expressed in expression ② above by a conjugate complex number (Pilot*) of the pilot symbol (Pilot).

$$\begin{aligned} \text{Profile1} &= R1 \times e^{j\theta^1} \times \text{Pilot} \times \text{Pilot}^* \\ &= R1 \times e^{j\theta^1} \times |\text{Pilot}|^2 \quad -\textcircled{3} \end{aligned}$$

where, if $|\text{Pilot}|^2 = 1$, expression ③ above can be expressed in the following expression:

$$\text{Profile1} = R1 \times e^{j\theta^1} \quad -\textcircled{4}$$

10 The transmission path characteristic (Profile1) obtained is sent to division section 64.

On the other hand, level detection section 63 calculates reception power of the reception signal (RX1). The reception power of the reception signal (RX1) is $R1^2$ from expression ① above. The reception power of the reception signal (RX1) is sent to division section 64.

Division section 64 performs the following division processing using the transmission path characteristic (Profile1) from complex multiplication section 62 and the reception power from level detection section 63.

$$\text{Pfifile1}/R1^2 = e^{j\theta^1}/R1 \quad -\textcircled{5}$$

The result of the division processing in division section 64 is sent to multiplication section 65.

25 Multiplication section 65 performs transmission path compensation on the reception signal using the result of the division processing in division section 64. That is, a demodulated signal is obtained by

of the pilot symbol section in each packet differs from the channel condition at the time of reception of the message section of the packet above. Thus, transmission path compensation is performed on the message section above using the transmission path characteristic estimated by the pilot symbol section above, and therefore the error rate characteristic of the demodulated signal obtained in the message section above deteriorates a great deal.

10 On the other hand, the conventional OFDM communication apparatus that carries out delay detection outputs the result of multiplying the signal at the current time by the signal preceding by 1 OFDM symbol as a demodulated signal, and therefore an error caused by a transmission path variation included in this demodulated signal is only 1 OFDM symbol. Thus, if the communication speed of one packet is slower than the channel variation speed, deterioration of the error rate characteristic of the demodulated signal is small.

20 On the other hand, in the conventional OFDM communication apparatus that carries out delay detection, the noise component superimposed on the demodulated signal doubles by multiplying the signal at the current time by the signal preceding by 1 OFDM symbol, and therefore if the communication speed of one packet is sufficiently faster than the channel variation speed, the error rate characteristic of the demodulated signal deteriorates compared to the conventional OFDM

communication apparatus that carries out coherent detection.

As shown above, in the conventional OFDM communication apparatuses above, the error rate
5 characteristic of the demodulated signal may deteriorate depending on the relationship between the communication speed of one packet and channel variation speed.

SUMMARY OF THE INVENTION

10

It is an object of the present invention to provide an OFDM communication apparatus that will suppress deterioration of the error rate characteristic of the demodulated signal. This object is attained by the
15 reception system performing demodulation processing on the reception signal according to factors that influence the quality of the demodulated signal. Furthermore, this object is attained by the transmission system performing modulation processing on the transmission
20 signal according to the demodulation processing carried out by the other end of communication.

BRIEF DESCRIPTION OF THE DRAWINGS

25

The above and other objects and features of the invention will appear more fully hereinafter from a consideration of the following description taken in connection with the accompanying drawing wherein one

example is illustrated by way of example, in which;

FIG.1 is a block diagram showing a configuration of a conventional OFDM communication apparatus that carries out coherent detection;

5 FIG.2 is a schematic diagram showing a frame format used by an OFDM communication apparatus;

FIG.3 is a block diagram showing an internal configuration of a coherent detection section of the conventional OFDM communication apparatus that carries
10 out coherent detection;

FIG.4 is a block diagram showing a configuration of a conventional OFDM communication apparatus that carries out delay detection;

FIG.5 is a block diagram showing an internal
15 configuration of a delay detection section of the conventional OFDM communication apparatus that carries out delay detection;

FIG.6 is a block diagram showing a configuration of an OFDM communication apparatus according to
20 Embodiment 1 of the present invention;

FIG.7 is a block diagram showing a configuration of an OFDM communication apparatus according to Embodiment 2 of the present invention; and

FIG.8 is a block diagram showing an internal
25 configuration of a demodulation section of the OFDM communication apparatus according to Embodiment 2 of the present invention.

DETAILED DESCRIPTION OF THE
PREFERRED EMBODIMENTS

With reference now to the attached drawings,
5 embodiments of the present invention will be explained
in detail below.

(Embodiment 1)

FIG.6 is a block diagram showing a configuration
10 of an OFDM communication apparatus according to
Embodiment 1 of the present invention. In the
transmission system in FIG.6, a transmission signal is
sent to QPSK modulation section 101 and DQPSK modulation
section 102. QPSK modulation section 101 performs QPSK
15 modulation on the transmission signal above for every
subcarrier. The QPSK-modulated transmission signal is
output to selection section 103.

DQPSK modulation section 102 performs DQPSK
modulation on the transmission signal above. The
20 DQPSK-modulated transmission signal is output to
selection section 103.

Selection section 103 receives, as an input, a
control signal from timing generation section 110 as to
which signal should be output to IFFT section 104, the
25 signal from QPSK modulation section 101 or the signal
from DQPSK modulation section 102. That is, when the
communication speed of one packet is sufficiently faster
than the channel variation speed, timing generation

section 110 outputs to selection section 103 a control signal instructing that the signal from QPSK modulation section 101 should be output to IFFT section 104. On the contrary, when the communication speed of one packet is
5 slower than the channel variation speed, timing generation section 110 outputs a control signal instructing that the signal from DQPSK modulation section 102 should be output to IFFT section 104. Here, the communication speed of one packet refers to a speed
10 when the apparatus on the transmitting side transmits one packet and the apparatus on the receiving side completes the reception of this packet.

Here, the relationship between the channel variation speed used in timing generation section 110
15 and communication speed of one packet can be decided from, for example, the quality (error rate characteristic, etc.) of a demodulated signal output from selection section 109 of the reception system, which will be described later.

20 Selection section 103 outputs either the signal from QPSK modulation section 101 or the signal from DQPSK modulation section 102 to IFFT section 104 based on the control signal from timing generation section 110.

IFFT section 104 performs IFFT processing on the
25 signal sent from selection section 103. In this way, the signal sent from selection section 103 is frequency-division multiplexed and sent to the other end of communication via antenna 105.

The frame configuration of the signal sent via antenna 105 is as shown in FIG.2 referred to previously. Each signal with the frame configuration shown in FIG.2 is sent carried on one packet.

5 In the reception system in FIG.6, the signal sent from the other end of communication is received via antenna 105. Here, the other end of communication has the same configuration as that shown in FIG.6 and the signal sent from this other end of communication is
10 subjected to the same processing as that in the transmission system described above.

The signal received via antenna 105 is subjected to FFT processing by FFT section 106. In this way, the signal sent through each subcarrier is extracted and
15 output to coherent detection section 107 and delay detection section 108.

Coherent detection section 107 performs coherent detection processing on the signal extracted by FFT section 106 and extracts a demodulated signal. Delay
20 detection section 108 performs delay detection processing on the signal extracted by FFT section 106 and extracts a demodulated signal. Both the demodulated signal extracted from coherent detection section 107 and demodulated signal extracted from delay detection
25 section 108 are output to selection section 109.

Selection section 109 receives, as an input, a control signal from timing generation section 110 as to which signal should be output as the demodulated signal,

the signal from coherent detection section 107 or the signal from delay detection section 108. More specifically, when the communication speed of one packet is sufficiently faster than the channel variation speed (when a QPSK-modulated signal from the other end of communication via antenna 105 is received via antenna 105), timing generation section 110 outputs a control signal instructing that a signal from coherent detection section 107 should be output to IFFT section 104 as the demodulated signal. On the contrary, when the communication speed of one packet is slower than the channel variation speed (when the signal DQPSK-modulated from the other end of communication is received via antenna 105), timing generation section 110 outputs a control signal instructing that a signal from delay detection section 108 should be output as the demodulated signal.

Selection section 109 outputs either the signal from coherent detection section 107 or signal from delay detection section 108 as the demodulated signal based on the control signal from timing generation section 110. In this way, when the communication speed of one packet is sufficiently faster than the channel variation speed, the reception signal is subjected to coherent detection processing and a demodulated signal is extracted. On the contrary, when the communication speed of one packet is slower than the channel variation speed, the reception signal is subjected to delay detection processing and

a demodulated signal is extracted.

As shown above, according to this embodiment, the reception system performs demodulation processing of either coherent detection processing or delay detection processing on the reception signal according to whether the communication speed of one packet is faster or slower than the channel variation speed, that is, the relationship between the communication speed of one packet and the channel variation speed. This makes it possible to suppress deterioration of the error rate characteristic of the demodulated signal. Furthermore, the transmission system performs modulation processing (QPSK modulation or DQPSK modulation) corresponding to the demodulation processing carried out by the other end of communication on the transmission signal, and therefore the other end of communication above can reliably suppress deterioration of the error rate characteristic of the demodulates signal.

This embodiment describes the case where the reception system uses two kinds of demodulation system, coherent detection and delay detection, while the transmission system uses two kinds of modulation system, QPSK modulation and DQPSK modulation, but the present invention is not limited to this and is also applicable when both reception system and transmission system use 3 or more types of demodulation system and modulation system, respectively. For example, it is possible to use BPSK modulation or 8PSK modulation, etc. as the

modulation system for the transmission system to allow the reception system to carry out delay detection processing.

Furthermore, this embodiment describes the case where a relationship between the communication speed of one packet and channel variation speed is used as the selection criteria of the demodulation system for the reception system and modulation system for the transmission system. But it goes without saying that the present invention is not limited to this, and it is also applicable to cases where simply the communication speed of one packet (length of one packet), channel variation speed or various factors that have influence on the quality of a demodulated signal (error rate characteristic, etc.) in the reception system are used as the selection criteria.

(Embodiment 2)

Embodiment 2 provides a mode of further reducing the scale of hardware by configuring the coherent detection section and delay detection section in Embodiment 1 with a single circuit. The OFDM communication apparatus according to this embodiment will be explained with reference to FIG.7 and FIG.8 below.

FIG.7 is a block diagram showing a configuration of the OFDM communication apparatus according to Embodiment 2 of the present invention. FIG.8 is a block

diagram showing an internal configuration of the demodulation section of the OFDM communication apparatus according to Embodiment 2 of the present invention. The parts in FIG.7 with the same configuration as that in Embodiment 1 (FIG.6) are assigned the same reference numerals as those in FIG.6 and their detailed explanations will be omitted.

In FIG.7, when a QPSK-modulated signal is received from the other end of communication via antenna 105, timing generation section 202 outputs a control signal instructing that the signal extracted from FFT section 106 should be subjected to coherent detection processing to demodulation section 201. When a DQPSK-modulated signal is received from the other end of communication via antenna 105, timing generation section 202 outputs a control signal instructing that the signal extracted from FFT section 106 should be subjected to delay detection processing to demodulation section 201.

Demodulation section 201 carries out demodulation processing of either coherent detection processing or delay detection processing on the signal extracted by FFT section 106 based on the control signal from timing generation section 202. That is, when the communication speed of one packet is sufficiently faster than the channel variation speed, demodulation section 201 performs coherent detection processing on the signal extracted by FFT section 106, and on the contrary, when the communication speed of one packet is slower than the

channel variation speed, demodulation section 201 performs delay detection processing on the signal extracted by FFT section 106.

Then, the internal configuration of demodulation section 201 will be explained with reference to FIG.8. In FIG.8, a reception signal (RX) is sent via switching section 301 to complex multiplication section 302, level detection section 303 and multiplication section 305. This reception signal (RX) is the signal extracted by FFT section 106 shown in FIG.7.

Complex multiplication section 302 performs complex multiplication processing using the reception signal (RX) and a pilot symbol (Pilot) to estimate a transmission path characteristic. The estimated transmission path characteristic is sent to division section 304.

On the other hand, level detection section 303 calculates the reception power of the reception signal (RX). This reception power is sent to division section 304.

Division section 304 carries out division processing using the transmission path characteristic from complex multiplication section 302 and reception power from level detection section 303. The result of this division processing is sent to selection section 307.

On the other hand, delay section 306 delays the reception signal (RX) by 1 OFDM symbol and then sends

the reception signal to selection section 307.

Selection section 307 selects either the signal from delay section 306 or the signal from division section 304 as the output signal to multiplication section 305 based on the control information from timing generation section 202. That is, when the control signal from timing generation section 202 is a control signal instructing that coherent detection processing should be carried out, selection section 307 selects the signal from division section 304 as the output signal to multiplication section 305. On the contrary, when the control signal from timing generation section 202 is a control signal instructing that delay detection processing should be carried out, selection section 307 selects the signal from delay section 306 as the output signal to multiplication section 305.

Multiplication section 305 multiplies the reception signal (RX) by the signal selected by selection section 307. In this way, when the control signal from timing generation section 202 is a control signal instructing that coherent detection processing should be carried out, transmission path compensation for the reception signal is carried out using the estimated transmission path estimation information. Moreover, when the control signal from timing generation section 202 is a control signal instructing that delay detection processing should be carried out, multiplication processing is carried out between the signal at the

current time and the signal 1 OFDM symbol ahead and thereby delay detection processing is carried out on the reception signal (RX).

Thus, according to this embodiment, it is possible to further reduce the scale of hardware compared to Embodiment 1 by configuring the coherent detection section and delay detection section with a single circuit.

The OFDM communication apparatus according to the embodiment described above can be mounted on a communication terminal apparatus or base station apparatus in a digital mobile communication system.

① The OFDM reception apparatus according to the present invention adopts a configuration comprising

FFT processor for performing FFT processing on a reception signal;

a plurality of demodulator capable of performing mutually different demodulation processes on the FFT-processed reception signal; and

selector for selecting, among said plurality of demodulator, a demodulator that should perform the demodulation process on said FFT-processed reception signal according to a factor that influences the quality of a demodulated signal and letting the selected demodulator perform the demodulation process.

According to this configuration, demodulation processing on the reception signal is selected according to the factors that influence the quality of the

demodulated signal, and therefore it is possible to suppress deterioration of the error rate of the demodulated signal.

② The OFDM reception apparatus according to the present invention adopts such a configuration that the selector uses a relationship between the communication speed of one packet and channel variation speed as a factor that influences the quality of the demodulated signal.

According to this configuration, demodulation processing on the reception signal is selected according to the relationship between the communication speed of one packet and channel variation speed, and therefore it is possible to maintain the error rate characteristic of the demodulated signal in optimal conditions regardless of the length of one packet or channel variation speed.

③ The OFDM reception apparatus according to the present invention adopts such a configuration that the demodulation processes carried out by the plurality of demodulator are coherent detection processing or delay detection processing.

According to this configuration, demodulation processing of either coherent detection processing or delay detection processing is carried out on the reception signal according to factors that influence the quality of the demodulated signal, for example according to the relationship between the communication speed of

one packet and channel variation speed, and therefore it is possible to reliably suppress deterioration of the error rate characteristic of the demodulated signal.

④ The OFDM transmission apparatus according to the present invention adopts a configuration comprising modulator for performing modulation processing corresponding to demodulation processing performed by an OFDM reception apparatus on a transmission signal; and

IFFT processor for performing IFFT processing on the modulated transmission signal,

said OFDM reception apparatus comprising:

FFT processor for performing FFT processing on a reception signal;

a plurality of demodulator capable of performing mutually different demodulation processes on the FFT-processed reception signal; and

selector for selecting, among said plurality of demodulator, a demodulator that should perform the demodulation process on said FFT-processed reception signal according to factor that influences the quality of a demodulated signal and letting the selected demodulator perform the demodulation process.

According to this configuration, modulation processing is carried out on the transmission signal according to the demodulation processing performed by the other end of communication, and therefore the other end of communication can reliably suppress deterioration

of the error rate characteristic of the demodulated signal.

⑤ The OFDM communication apparatus according to the present invention adopts a configuration including
5 an OFDM reception apparatus comprising:

FFT processor for performing FFT processing on a reception signal;

a plurality of demodulator capable of performing mutually different demodulation processes on the
10 FFT-processed reception signal; and

selector for selecting, among said plurality of demodulator, a demodulator that should perform the demodulation process on said FFT-processed reception signal according to factor that influences the quality
15 of a demodulated signal and letting the selected demodulator perform the demodulation process, and an OFDM transmission apparatus comprising:

modulator for performing modulation processing corresponding to the demodulation processing performed
20 by said OFDM reception apparatus on a transmission signal; and

IFFT processor for performing IFFT processing on the modulated transmission signal.

According to this configuration, it is possible to
25 provide an OFDM communication apparatus that suppresses deterioration of the error rate characteristic of the demodulated signal.

⑥ The communication terminal apparatus according

to the present invention adopts a configuration equipped with an OFDM communication apparatus, said OFDM communication apparatus including an OFDM reception apparatus comprising:

5 FFT processor for performing FFT processing on a reception signal;

 a plurality of demodulator capable of performing mutually different demodulation processes on the FFT-processed reception signal; and

10 selector for selecting, among said plurality of demodulator, a demodulator that should perform the demodulation process on said FFT-processed reception signal according to factor that influences the quality of a demodulated signal and letting the selected

15 demodulator perform the demodulation process, and

 an OFDM transmission apparatus comprising:

 modulator for performing modulation processing corresponding to the demodulation processing performed by said OFDM reception apparatus on a transmission

20 signal; and

 IFFT processor for performing IFFT processing on the modulated transmission signal.

 This configuration comprises an OFDM communication apparatus that suppresses deterioration of the error

25 rate characteristic of the demodulated signal, and therefore can provide a communication terminal apparatus capable of executing optimal communications.

⑦ The base station apparatus according to the

006080" 9605E960

present invention adopts a configuration equipped with an OFDM communication apparatus, said OFDM communication apparatus including an OFDM reception apparatus comprising:

5 FFT processor for performing FFT processing on a reception signal;

 a plurality of demodulator capable of performing mutually different demodulation processes on the FFT-processed reception signal; and

10 selector for selecting, among said plurality of demodulator, a demodulator that should perform the demodulation process on said FFT-processed reception signal according to factor that influences the quality of a demodulated signal and letting the selected

15 demodulator perform the demodulation process, and

 an OFDM transmission apparatus comprising:

 modulator for performing modulation processing corresponding to the demodulation processing performed by said OFDM reception apparatus on a transmission

20 signal; and

 IFFT processor for performing IFFT processing on the modulated transmission signal.

 This configuration comprises an OFDM communication apparatus that suppresses deterioration of the error
25 rate characteristic of the demodulated signal, and therefore can provide a communication terminal apparatus capable of executing optimal communications.

⑧ The OFDM communication method according to the

006090 960960

the FFT step of performing FFT processing on a reception signal; and

the demodulating step of performing, among a plurality of demodulation processes, a demodulation process corresponding to factor that influences the quality of a modulated signal.

According to this method of the present invention, demodulation processing on the reception signal is selected according to the factors that influence the quality of the demodulated signal, and therefore it is possible to suppress deterioration of the error rate of the demodulated signal.

⑨ The OFDM communication method according to the present invention adopts a method with the demodulating step using a relationship between the communication speed of one packet and channel variation speed as a factor that influences the quality of a demodulated signal.

20 According to this method, demodulation processing
on the reception signal is selected according to the
relationship between the communication speed of one
packet and channel variation speed, and therefore it is
possible to maintain the error rate characteristic of
25 the demodulated signal in optimal conditions regardless
of the length of one packet or channel variation speed.

Selection of coherent detection or delay detection

according to the channel variation speed can also be applied to a single carrier system. However, since delay detection performs a multiplication between the current symbol and the immediately preceding symbol,

5 interference between codes increases in a multi-path environment. Thus, applying delay detection to the single carrier system causes characteristic deterioration due to interference between codes to increase a great deal. Thus, in the case where the
10 present invention is applied to the single carrier system, an optimal error rate characteristic irrespective of the channel variation speed may not always be obtained.

On the other hand, the OFDM system can prevent interference between codes even in a multi-path
15 environment by inserting a guard interval for every symbol. Thus, applying selection of coherent detection or delay detection according to the channel variation speed to an OFDM system can obtain an optimal error rate characteristic regardless of the channel variation
20 speed.

As described above, the present invention performs demodulation processing according to factors that influence the quality of a demodulated signal, and
25 therefore can provide an OFDM communication apparatus that suppresses deterioration of the error rate characteristic of the demodulated signal.

The present invention is not limited to the above

described embodiments, and various variations and modifications may be possible without departing from the scope of the present invention.

This application is based on the Japanese Patent
5 Application No. HEI 11-253633 filed on September 7, 1999,
entire content of which is expressly incorporated by
reference herein.

09635096-0800900

What is claimed is:

1. An OFDM reception apparatus comprising:

FFT processor for performing FFT processing on a
5 reception signal;

a plurality of demodulator capable of performing
mutually different demodulation processes on the
FFT-processed reception signal; and

selector for selecting, among said plurality of
10 demodulator, a demodulator that should perform the
demodulation process on said FFT-processed reception
signal according to a factor that influences the quality
of a demodulated signal and letting the selected
demodulator perform the demodulation process.

15

2. The OFDM reception apparatus according to claim 1,
wherein the selector uses a relationship between the
communication speed of one packet and channel variation
speed as a factor that influences the quality of the
20 demodulated signal.

3. The OFDM reception apparatus according to claim 1,
wherein the demodulation processes carried out by the
plurality of demodulator are coherent detection
25 processing or delay detection processing.

4. An OFDM transmission apparatus comprising:

modulator for performing modulation processing

corresponding to demodulation processing performed by
an OFDM reception apparatus on a transmission signal;
and

IFFT processor for performing IFFT processing on
5 the modulated transmission signal,

said OFDM reception apparatus comprising:

FFT processor for performing FFT processing on a
reception signal;

a plurality of demodulator capable of performing
10 mutually different demodulation processes on the
FFT-processed reception signal; and

selector for selecting, among said plurality of
demodulator, a demodulator that should perform the
demodulation process on said FFT-processed reception
15 signal according to factor that influences the quality
of a demodulated signal and letting the selected
demodulator perform the demodulation process.

5. An OFDM communication apparatus equipped with an OFDM
20 reception apparatus comprising:

FFT processor for performing FFT processing on a
reception signal;

a plurality of demodulator capable of performing
mutually different demodulation processes on the
25 FFT-processed reception signal; and

selector for selecting, among said plurality of
demodulator, a demodulator that should perform the
demodulation process on said FFT-processed reception

signal according to factor that influences the quality of a demodulated signal and letting the selected demodulator perform the demodulation process, and

an OFDM transmission apparatus comprising:

5 modulator for performing modulation processing corresponding to the demodulation processing performed by said OFDM reception apparatus on a transmission signal; and

10 IFFT processor for performing IFFT processing on the modulated transmission signal.

6. A communication terminal apparatus equipped with an OFDM communication apparatus, said OFDM communication apparatus including an OFDM reception apparatus

15 comprising:

FFT processor for performing FFT processing on a reception signal;

a plurality of demodulator capable of performing mutually different demodulation processes on the

20 FFT-processed reception signal; and

selector for selecting, among said plurality of demodulator, a demodulator that should perform the demodulation process on said FFT-processed reception signal according to factor that influences the quality

25 of a demodulated signal and letting the selected demodulator perform the demodulation process, and

an OFDM transmission apparatus comprising:

modulator for performing modulation processing

006080" 9605E960

corresponding to the demodulation processing performed by said OFDM reception apparatus on a transmission signal; and

IFFT processor for performing IFFT processing on
5 the modulated transmission signal.

7. A base station apparatus equipped with an OFDM communication apparatus, said OFDM communication apparatus including an OFDM reception apparatus
10 comprising:

FFT processor for performing FFT processing on a reception signal;

a plurality of demodulator capable of performing mutually different demodulation processes on the
15 FFT-processed reception signal; and

selector for selecting, among said plurality of demodulator, a demodulator that should perform the demodulation process on said FFT-processed reception signal according to factor that influences the quality
20 of a demodulated signal and letting the selected demodulator perform the demodulation process, and

an OFDM transmission apparatus comprising:

modulator for performing modulation processing corresponding to the demodulation processing performed
25 by said OFDM reception apparatus on a transmission signal; and

IFFT processor for performing IFFT processing on the modulated transmission signal.

006080" 96052960

8. An OFDM communication method comprising:

the FFT step of performing FFT processing on a reception signal; and

5 the demodulating step of performing, among a plurality of demodulation processes, a demodulation process corresponding to factor that influences the quality of a modulated signal.

10 9. The OFDM communication method according to claim 8, wherein the demodulating step uses a relationship between the communication speed of one packet and channel variation speed as a factor that influences the quality of the demodulates signal.

ABSTRACT OF THE DISCLOSURE

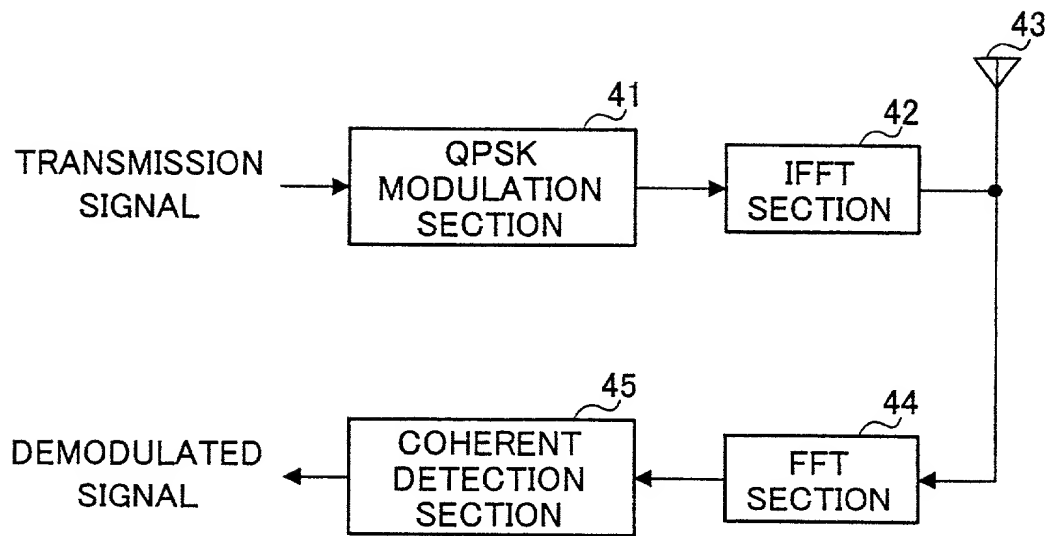
The OFDM reception apparatus according to the present invention comprising:

5 FFT processor for performing FFT processing on a reception signal;

 a plurality of demodulator capable of performing mutually different demodulation processes on the FFT-processed reception signal; and

10 selector for selecting, among said plurality of demodulator, a demodulator that should perform the demodulation process on said FFT-processed reception signal according to a factor that influences the quality of a demodulated signal and letting the selected
15 demodulator perform the demodulation process.

005050" 0505050



PRIOR ART
FIG.1

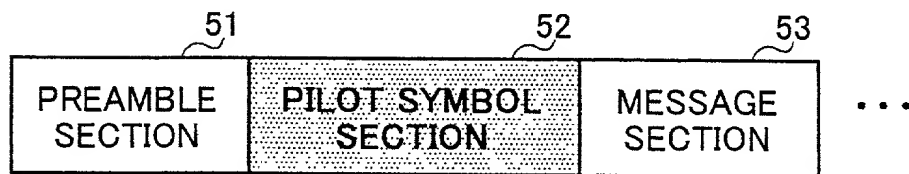
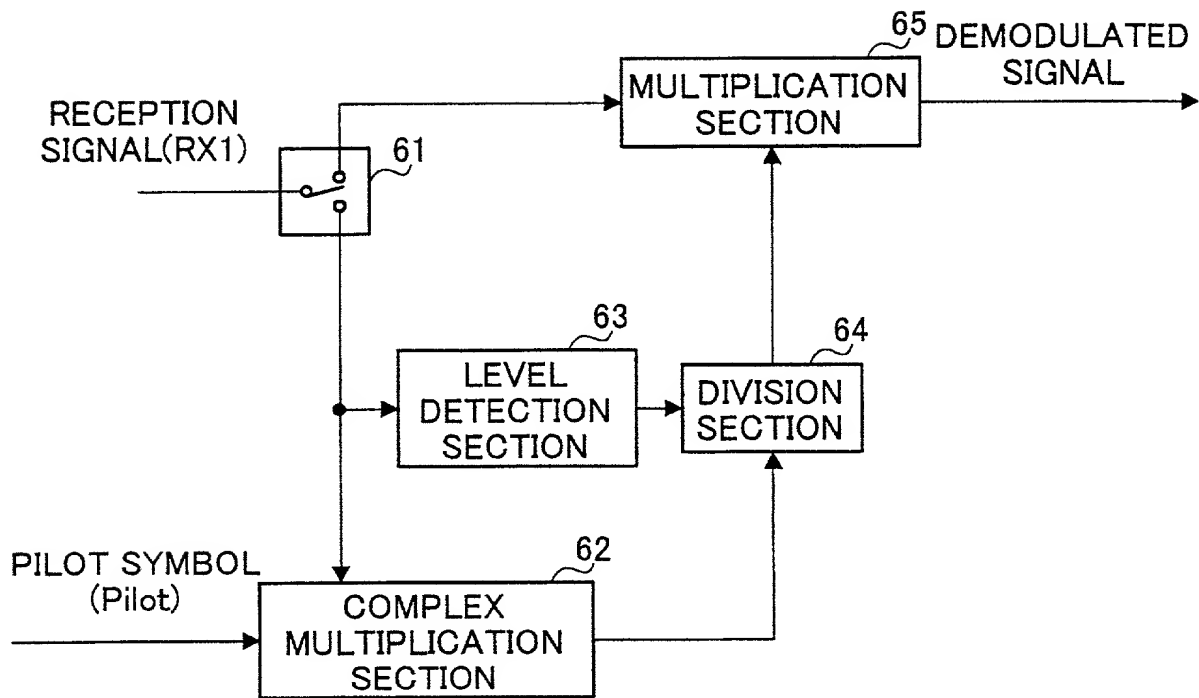
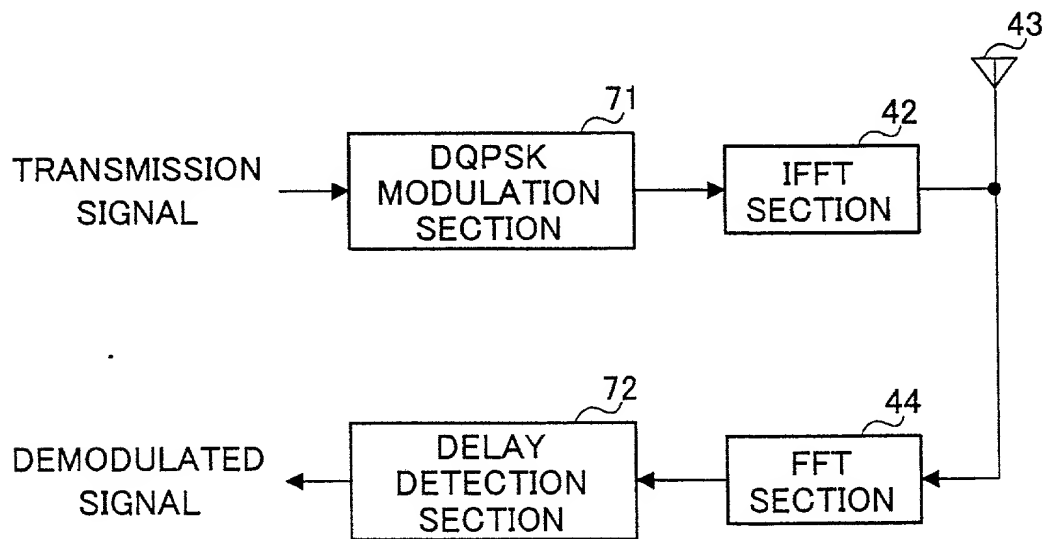


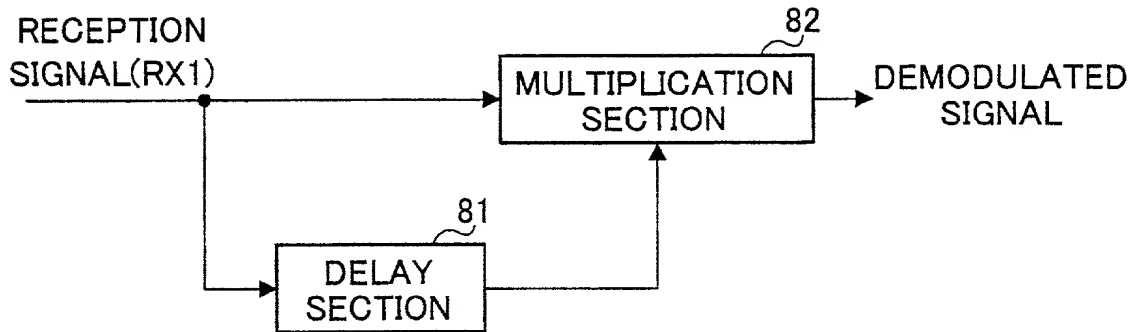
FIG.2



PRIOR ART
FIG.3



PRIOR ART
FIG.4



PRIOR ART
FIG.5

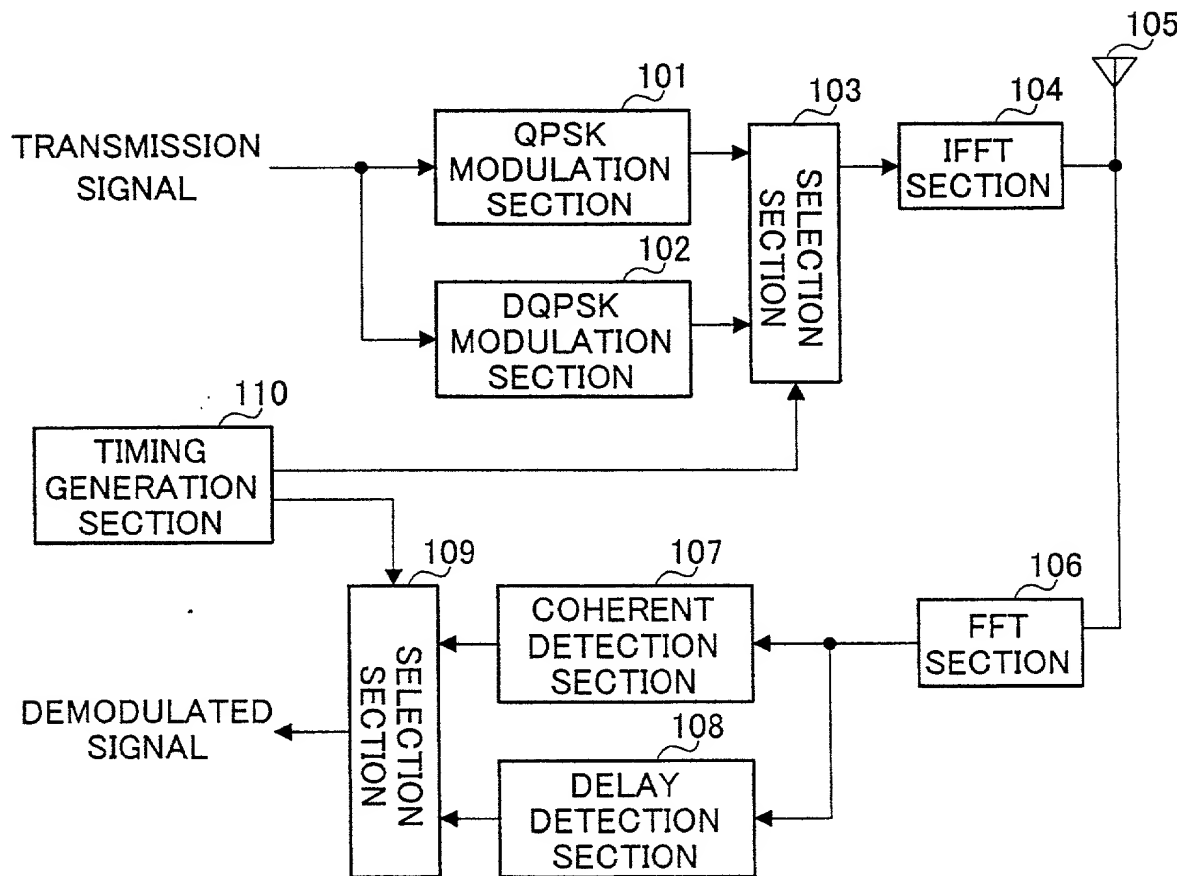


FIG.6

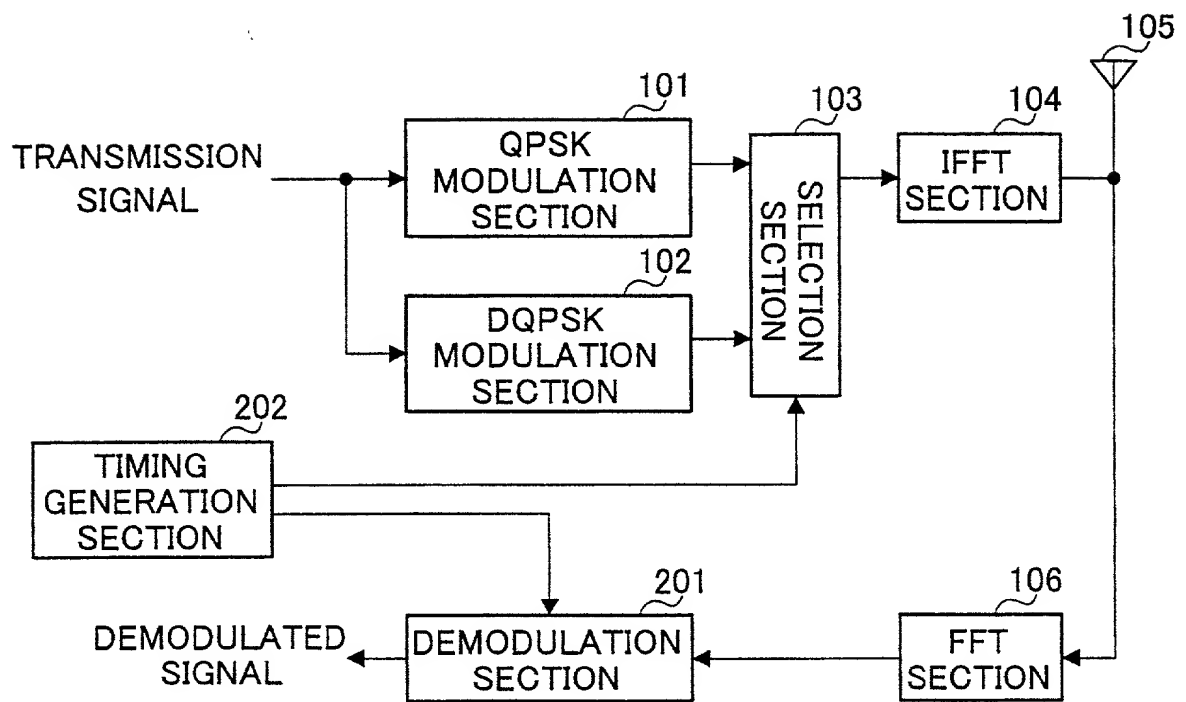


FIG.7

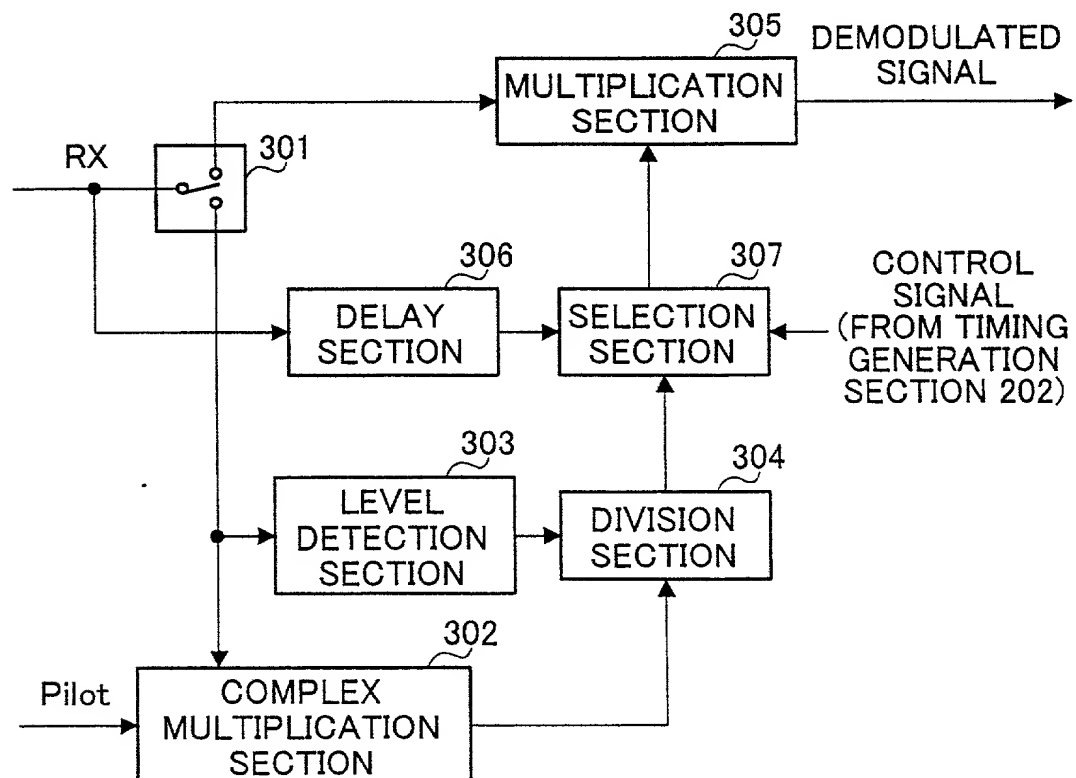


FIG.8

APPLICATION FOR UNITED STATES PATENT
Declaration for Patent Application

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on

the invention entitled: APPARATUS AND METHOD FOR OFDM COMMUNICATION

the specification of which 2 (file no.)

(check at least one) 3 ☒ is attached hereto

4 ☐ was filed on as (5) U.S. Application Serial No.

6 ☐ and was amended
(if applicable)

Use this portion only if you are entering the U.S. National phase based on a PCT International Application designating the U.S.	<u>7</u> <input type="checkbox"/>	was filed as PCT international application
	<u>8</u>	Number <u> </u>
	<u>9</u>	on <u> </u>
	and was amended under PCT Article(s) 19 and/or 34	
	<u>10</u>	on <u> </u> (if applicable).

I hereby declare that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed.

Prior (Foreign) Application(s) any Priority Claims Under 35 U.S.C. 119 Priority Claimed

11a	<u>Japan</u>	<u>H11-253633</u>	<u>07/09/1999</u>	<u>[x]</u>	<u>[]</u>
	(Country)	(Number)	(Day/Month/Year Filed)	Yes	No

<u> </u>	<u> </u>	<u> </u>	<u>[]</u>	<u>[]</u>
(Country)	(Number)	(Day/Month/Year Filed)	Yes	No

☐ Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.

Priority Claim(s) from U.S. Provisional Application(s) – I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

11b	<u> </u>	<u> </u>	<u> </u>	<u> </u>
	Application No.	Day/Month/Year Filed	Application No.	Day/Month/Year Filed

Do not use this portion to identify a PCT application if the parent application is the U.S. National phase of the PCT application	I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between filing date of the prior application and the national or PCT international filing date of this application.		
	<u>13</u>	<u> </u>	<u> </u>
	(U.S. Application Number)	(U.S. Filing Date)	Status (patented, pending, abandoned)

I hereby appoint the following attorneys of the firm of Stevens, Davis, Miller & Mosher, L.L.P. as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent and Trademark Office:

James E. Ledbetter, Reg. No. 28732; Thomas P. Pavelko, Reg. No. 31689; and Anthony P. Venturino, Reg. No. 31674.

ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO
STEVENS, DAVIS, MILLER & MOSHER, L.L.P., 1615 L Street, N.W., Suite 850, Washington, D.C. 20036,
TELEPHONE (202) 408-5100, FACSIMILE (202) 408-5200.

See page 2 for signature lines

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

PAGE 2 OF U.S.A. DECLARATION FORM

13a	Typewritten Full Name of Sole or First Inventor	Hiroaki	SUDO
		Given Name	Middle Name
14a	Inventor's Signature	<i>Hiroaki</i>	<i>Sudo</i>
15a	Date of Signature	<i>June</i>	<i>21</i>
		Month	Day
			<i>2000</i>
			Year
16a	Residence	Yokohama-shi	Kanagawa
		City	State or Province
			JAPAN
			Country
17a	Citizenship	JAPAN	
18a	Post Office Address (Insert complete mailing address, including country)	508, Saedo-cho, Tsuzuki-ku, Yokohama-shi, Kanagawa 224-0054 JAPAN	
13b	Typewritten Full Name of Sole or First Inventor		
		Given Name	Middle Name
14b	Inventor's Signature		
15b	Date of Signature		
		Month	Day
			Year
16b	Residence		
		City	State or Province
			Country
17b	Citizenship		
18b	Post Office Address (Insert complete mailing address, including country)		
13c	Typewritten Full Name of Sole or First Inventor		
		Given Name	Middle Name
14c	Inventor's Signature		
15c	Date of Signature		
		Month	Day
			Year
16c	Residence		
		City	State or Province
			Country
17c	Citizenship		
18c	Post Office Address (Insert complete mailing address, including country)		
13d	Typewritten Full Name of Sole or First Inventor		
		Given Name	Middle Name
14d	Inventor's Signature		
15d	Date of Signature		
		Month	Day
			Year
16d	Residence		
		City	State or Province
			Country
17d	Citizenship		
18d	Post Office Address (Insert complete mailing address, including country)		

*Note to Inventor: Please sign name on line 15 exactly as it appears in line 14 and insert the actual date of signing on line 16. If there are more than four inventors, please add a copy of this page for identification and signatures for the additional inventors.